

Claims

- [c1] 1. A method of operating a hybrid electric vehicle having an internal combustion engine and an electric machine which is operatively coupled to, and selectively provides torque to, the engine, the method comprising: detecting at least one of a cold-start condition and a transient event; and selectively providing a torque to the engine by use of the electric machine, the torque having a value based on the detection and being effective to alter operation of the engine in a manner which reduces exhaust emissions.
- [c2] 2. The method of claim 1, wherein the vehicle includes a catalytic converter which receives exhaust gas from the engine and which operates at a certain efficiency based on a temperature of the catalytic converter, and wherein the value of the torque is negative when a cold-start condition is detected, the negative torque being effective to increase a power output of the engine, thereby increasing the temperature and the certain efficiency of the catalytic converter.
- [c3] 3. The method of claim 2, further comprising providing a lean air-fuel ratio to the engine during a detected cold-

start condition.

[c4] 4. The method of claim 2, wherein the engine has a certain spark timing, the method further comprising retarding the spark timing of the engine during a detected cold-start condition.

[c5] 5. The method of claim 4, further comprising:
measuring the temperature of the catalytic converter;
and
terminating the negative torque and the retarded spark timing when the catalytic converter temperature exceeds a predetermined threshold.

[c6] 6. The method of claim 1, wherein the vehicle includes a catalytic converter which receives exhaust gas from the engine and which operates at a certain efficiency based on a temperature of the catalytic converter, and wherein the value of the torque is positive when a transient event is detected, the positive torque being effective to supplement torque provided by the engine and lower a power output of the engine, thereby lowering exhaust mass flow through the catalytic converter and reducing emissions.

[c7] 7. The method of claim 6, further comprising slowly lowering the positive torque provided by the electric ma-

chine.

- [c8] 8. The method of claim 7, wherein the transient event is detected by monitoring torque demands on the engine.
- [c9] 9. The method of claim 8, wherein the transient event is detected when the torque demands exceed a predetermined value.
- [c10] 10. A method of operating a hybrid electric vehicle having a drive train, an electric machine which selectively provides torque to the drive train, an engine which selectively provides torque to the drive train and which operates at a certain power output, and a catalytic converter which receives exhaust gas from the engine, the method comprising:
detecting a transient event; and
selectively providing a positive torque to the drive train by use of the electric machine, the positive torque being effective to supplement the torque provided by the engine and lower the certain power output, thereby lowering exhaust mass flow through the catalytic converter and reducing emissions.
- [c11] 11. The method of claim 10, wherein said electric machine comprises a motor/generator.
- [c12] 12. The method of claim 10, further comprising slowly

lowering the positive torque provided by the electric machine while raising the torque provided by the engine.

[c13] 13. The method of claim 12, wherein the transient event is detected by monitoring torque demands to the engine.

[c14] 14. The method of claim 12, wherein the transient event is detected when the torque demands exceed a predetermined value.

[c15] 15. A hybrid electric vehicle, comprising:
an engine;
an electric machine operatively coupled to the engine and capable of selectively applying a torque to the engine;
a plurality of sensors for measuring vehicle operating conditions, each of the sensors being capable of outputting a signal related to a corresponding vehicle operating condition; and
a controller in communication with the engine, the electric machine, and the sensors, the controller being configured to detect at least one of a cold-start condition and a transient event, the detection being based on at least some of the measured vehicle operating conditions, the controller being further configured to command the electric machine to provide torque to the engine based on the detection, the torque being effective to alter op-

eration of the engine to reduce exhaust emissions.

[c16] 16. The hybrid electric vehicle of claim 15, further comprising a catalytic converter having a temperature dependent efficiency, the catalytic converter being disposed to receive exhaust gas from the engine; and wherein the controller commands the electric machine to provide a negative torque to the engine when a cold-start condition is detected, the negative torque being effective to increase a power output of the engine, thereby increasing the temperature and the efficiency of the catalytic converter.

[c17] 17. The hybrid electric vehicle of claim 16, wherein the controller is further configured to cause a lean air-fuel ratio to be provided to the engine, and to selectively retard a spark timing of the engine, when a cold-start is detected.

[c18] 18. The hybrid electric vehicle of claim 17, wherein at least one of the sensors is configured to measure a temperature of the catalytic converter, and the controller is further configured to command the electric machine to terminate the negative torque to the engine and the retarded spark timing of the engine, when the measured catalytic converter temperature exceeds a predetermined threshold.

[c19] 19. The hybrid electric vehicle of claim 15, further comprising a catalytic converter having a temperature dependent efficiency, the catalytic converter being disposed to receive exhaust gas from the engine; and wherein the controller commands the electric machine to provide a positive torque to the engine when a transient event is detected, the positive torque being effective to supplement torque provided by the engine and lower a power output of the engine, thereby lowering exhaust mass flow through the catalytic converter and reducing emissions.

[c20] 20. The hybrid electric vehicle of claim 19, wherein the controller is configured to detect a transient event based on torque demands on the engine.